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A SIMPLE NODE AND CONDUCTOR DATA GENERATOR FOR SINDA

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SUMMARY

This paper presents a simple, automated method to generate NODE and CONDUCTOR DATA for thermal math models. The method uses personal computer spreadsheets to create SINDA inputs. It was developed in order to make SINDA modeling less time consuming and serves as an alternative to graphical methods.

Anyone having some experience using a personal computer can easily implement this process. The user develops spreadsheets to automatically calculate capacitances and conductances based on material properties and dimensional data. The necessary node and conductor information is then taken from the spreadsheets and automatically arranged into the proper format, ready for insertion directly into the SINDA model.

This technique provides a number of benefits to the SINDA user such as a reduction in the number of hand calculations, and an ability to very quickly generate a parametric set of NODE and CONDUCTOR DATA blocks. It also provides advantages over graphical thermal modeling systems by retaining the analyst's complete visibility into the thermal network, and by permitting user comments anywhere within the DATA blocks.

INTRODUCTION

There continues to be a need to more fully automate thermal modeling. As a member of the engineering team, the thermal analyst is being asked to perform more comprehensive studies on more complex systems, and to do so in less time.

Over the years, a number of techniques have been developed to make thermal modeling more productive. For instance, various computer programs have been written for transforming finite element models into "equivalent" finite difference models (refs. 1, 2, 3, 4, 5). Other systems avoid finite differences altogether and solve for temperatures directly using the finite element formulation (refs. 6, 7, 8, 9, 10).

However, many thermal analysts do not have access to or training on these graphical systems. Recognizing these constraints, a new thermal network generator utilizing a personal computer spreadsheet program was devised.

IMPLEMENTATION

All that is needed to implement this method is a personal computer, a spreadsheet program, a programming language compiler, and a way to transfer files from the PC to the computer used to run SINDA.

NODE DATA GENERATOR

The first step is to construct a NODE DATA spreadsheet, similar to the one in Figure 1, which calculates nodal capacitances. One node is defined on each row of the spreadsheet. Each column contains a different type of information about the node, such as the node number, initial temperature, material properties, and dimensions. The cell in the next-to-last column contains an equation which calculates the nodal capacitance as a function of the material properties and dimensions. The last column contains a comment to be added at the end of that NODE DATA record.

Several rows in the spreadsheet begin with "C" or "C ***". These will serve as comment lines in the finished NODE DATA block.

Some of the cells in the "Area" column have a "-". For these nodes, the volume calculation is a product of the thickness, width and length.

Some of the cells in the "Thickness" and "Width" columns have a "-". For these nodes, the volume calculation is a product of the cross-sectional area and length.

In order to remain consistent with SINDA NODE DATA input codes, arithmetic nodes are defined by entering a capacitance value of "-1.0". Similarly, boundary and heater nodes are defined by entering negative node numbers.

Once the spreadsheet is completed, it should be written to disk (saved) as usual. But before exiting the spreadsheet program, the information needs also to be saved in ASCII form so that it can eventually be taken to the SINDA model. In Microsoft Excel, for instance, the "Save As..." command is used, and the CSV (comma separated values) file format option is chosen. This produces a file similar to the one shown in Figure 2.

The CSV file contains some data that is not useful (nor legal) in the SINDA NODE DATA block. Therefore, the user must write a simple FORTRAN or BASIC program which will read in the CSV file and write out the NODE DATA in proper SINDA format. A sample BASIC program which does this, NODE.BAS, is shown in Figure 3.

NODE.BAS reads in the CSV file one line at a time. All lines before "C" or "C ***" is encountered are ignored. Any lines beginning with "C" or "C ***" are written out as comment lines. All of the other lines contain actual NODE DATA. These are read in one value at a time, with the pertinent values (node number, initial temperature, capacitance, comment) written out in proper SINDA format. The resulting file, shown in Figure 4, is ready to be inserted directly into the SINDA model.

CONDUCTOR DATA GENERATOR

The CONDUCTOR DATA generator is very similar to the NODE DATA generator. An example is shown in Figures 5 through 8.

Some of the "Thickness" values in the CONDUCTOR DATA spreadsheet (Figure 5) are entered as "-". In these cases, the "Conductance" value is calculated using a cross-sectional area rather than a product of the thickness and width.

This spreadsheet can be used to consolidate a series of conductances into a single SINDA conductor. For example, conductor 19 in Figure 5 is a case where two conductances (one through a solid, the next through a joint) are consolidated into a single SINDA conductor. A simple KA/L is calculated in the "Conductance" column. A "Joint Conductance" is then calculated as a function of the number of fasteners in the joint. Finally, these two conductances are taken in series to calculate an equivalent "Final C'tance."

DISCUSSION

Using spreadsheets to generate NODE and CONDUCTOR DATA provides a number of advantages compared to traditional (non-automated) and graphical methods.

This method is perhaps as similar to traditional SINDA modeling as any automated method can be. The spreadsheets look very much like the actual NODE and CONDUCTOR DATA blocks, including "-1.0" capacitances for arithmetic and heater nodes, negative node numbers for boundary and heater nodes, "dollar sign" comments at the ends of records, and a "C" in column one for comment lines. Because of these similarities, practically any SINDA user can quickly understand and use the spreadsheets.

One productivity advantage is the user's ability to quickly edit material properties and dimensions. As any spreadsheet user knows, entire columns of entries can be edited very quickly. Parametric analysis becomes convenient by rapidly editing and saving an assortment of NODE and CONDUCTOR DATA blocks representing a variety of design alternatives. Once the node and conductor files are placed into the same directory as the SINDA model, the SINDA '85 INCLUDE statement can be used to automatically insert these external files into the SINDA model as appropriate.

Another productivity advantage is gained because of the virtual elimination of hand calculations. Once the spreadsheets have been developed and checked for accuracy, capacitance and conductance updates become immediate and remain accurate as design changes are incorporated.

A great deal of flexibility is possible using the spreadsheets. GEN, SIV and other SINDA NODE and CONDUCTOR DATA options may be incorporated. Parameters of any type may be included. Very complex equations can be defined. For example, a complicated joint conductance equation may be entered as a function of parameters such as clamping force, surface roughness, etc.

Another benefit of the spreadsheet method is that the thermal analyst, as well as his supervisor and the customer, continue to have full visibility into the thermal model network. Most graphical SINDA modelers make the computations and assumptions behind the capacitance and conductance values (and sometimes even the values themselves) transparent to the user. Also, they often use finite element to finite difference translations which create "cross conductors" or negative conductors. The resulting thermal networks can be difficult for some users to understand and scrutinize for validity.

Unlike most graphical modelers, the spreadsheet method permits a user to fully document the NODE and CONDUCTOR DATA since user comments may be inserted anywhere in the blocks.

The spreadsheet method allows a good paper trail to be maintained. Archived spreadsheet files and printouts can be kept to retain historical information. Most spreadsheet programs have an automatic date/time stamp capability. For example, the Microsoft Excel function "=NOW()" will read the date and time from the PC's internal clock and display them in a cell, as shown in Figures 1 and 5.

CONCLUSION

An automated method of generating NODE and CONDUCTOR DATA has been developed utilizing personal computer spreadsheets. The spreadsheet method has a "look and feel" familiar to SINDA users, provides relief from hand calculations, allows flexibility in capacitance and conductance formula definitions, retains visibility into the thermal network, and permits user comments anywhere in the DATA blocks.

The spreadsheet method is an attractive alternative to traditional SINDA modeling for those thermal analysts who cannot take advantage of graphical modelers.

REFERENCES

1. Anderson,T./Baum,F./Zarda,P.R., Thermal Analysis with Supertab and FEM/SINDA, SDRC 1988 I-DEAS/CAEDS Users' Conference Series, International Proceedings, SDRC, 2000 Eastman Drive, Milford, OH 45150-2789

2. SDRC I-DEAS TMG (Thermal Model Generator) User's Guide, Version 6.0, December 1991, MAYA Heat Transfer Technologies Ltd., 43 Thornhill, Montreal, P.Q., Canada H3Y 2E3

3. P/Thermal 2.3 User Manual, July 1988, PDA Engineering, PATRAN Division, 2975 Redhill Avenue, Costa Mesa, CA 92626

4. PAT/SINDA Application Interface Guide, Release 2.1A, March 1987, PDA Engineering, PATRAN Division, 2975 Redhill Avenue, Costa Mesa, CA 92626

5. ANSYS-SINDA/1987 Interface, Network Analysis Associates, Inc., 9972 Sage Circle, Fountain Valley, CA 92708

6. SDRC I-DEAS Model Solution User's Guide, Level 6.0, December 1990, SDRC, 2000 Eastman Drive, Milford, OH 45150-2789

7. P/FEA 2.3 User Manual, July 1988, PDA Engineering, PATRAN Division, 2975 Redhill Avenue, Costa Mesa, CA 92626

8. DeSalvo,G.J./Gorman,R.W., ANSYS Engineering Analysis System User's Manual, May 1, 1989, Swanson Analysis Systems, Inc., P. O. Box 65, Houston, PA 15342

9. Harder,R.L., MSC/NASTRAN Thermal Analysis, April 1986, MacNeal-Schwendler Corp., 815 Colorado Blvd., Los Angeles, CA 90041-1777

10. PCB Thermal User's Reference Manual, Version 2.2, 05 October 1990, Pacific Numerics Corporation, La Jolla, CA

NODE DATA for SINDA model 'SAMPLE.INP'									
This is spreadsheet file 'SAMPLE_N.XLS'									
Node Number	Init'l Temp	Mat'l Density	Mat'l Spec Ht	Thcknss	Width	Area	Length	Capacitance	Comments
C									
C *** THE FOLLOWING NODES WERE GENERATED BY 'SAMPLE_N.XLS'									
C *** ON 12 June 92, 2:16 PM									
C *** DIMENSIONS ARE FROM CAD MODEL 'STRUCTURE.MF1;14' 04 JUNE 92									
C *** ALUMINUM 2014-T6 PROPERTIES ARE FROM MIL-HDBK-5F, ROOM TEMP									
C									
C *** STRUCTURE NODES									
C *** STRUCTURE TORQUE BOX									
102	30.0	0.101	0.109	0.070	6.290	-	8.170	0.0396	$
105	30.0	0.101	0.109	0.070	6.290	-	8.170	0.0396	$
108	30.0	0.101	0.109	0.070	4.160	-	8.170	0.0262	$
109	30.0	0.101	0.109	0.070	4.160	-	8.170	0.0262	$
112	30.0	0.101	0.109	0.070	7.900	-	8.170	0.0497	$
152	30.0	0.101	0.109	0.070	6.290	-	7.970	0.0386	$
155	30.0	0.101	0.109	0.070	6.290	-	7.970	0.0386	$
158	30.0	0.101	0.109	0.070	4.160	-	7.970	0.0256	$
159	30.0	0.101	0.109	0.070	4.160	-	7.970	0.0256	$
162	30.0	0.101	0.109	0.070	7.900	-	7.970	0.0485	$
C									
C *** STRUCTURE WALL TRUSSES									
104	30.0	0.101	0.109	-	-	0.090	8.214	-1.0	$
204	30.0	0.101	0.109	-	-	0.090	4.215	-1.0	$
154	30.0	0.101	0.109	-	-	0.090	16.547	0.0164	$
361	30.0	0.101	0.109	-	-	0.090	9.300	-1.0	$
385	30.0	0.101	0.109	-	-	0.090	9.300	-1.0	$
C									
C									

Figure 1. NODE DATA Spreadsheet

```
NODE DATA for SINDA model 'SAMPLE.INP',,,,,,,,,
This is spreadsheet file 'SAMPLE_N.XLS',,,,,,,,,
,,,,,,,,,
Node,Init'l,Mat'l,Mat'l,,,,,,
Number,Temp,Density,Spec Ht,Thcknss,Width,Area,Length,Capacitance,Comments
,,,,,,,,,
C,,,,,,,,,
C *** THE FOLLOWING NODES WERE GENERATED BY 'SAMPLE_N.XLS',,,,,,,,,
C *** ON 12 June 92, 2:49 PM,,,,,,,,,
C *** DIMENSIONS ARE FROM CAD MODEL 'STRUCTURE.MF1;14' 04 JUNE 92,,,,,,,,,
C *** ALUMINUM 2014-T6 PROPERTIES ARE FROM MIL-HDBK-5F, ROOM TEMP,,,,,,,,,
C,,,,,,,,,
C *** STRUCTURE NODES,,,,,,,,,
C *** STRUCTURE TORQUE BOX,,,,,,,,,
102,30.0,0.101,0.109,0.070,6.290,-,8.170,0.0396,$
105,30.0,0.101,0.109,0.070,6.290,-,8.170,0.0396,$
108,30.0,0.101,0.109,0.070,4.160,-,8.170,0.0262,$
109,30.0,0.101,0.109,0.070,4.160,-,8.170,0.0262,$
112,30.0,0.101,0.109,0.070,7.900,-,8.170,0.0497,$
152,30.0,0.101,0.109,0.070,6.290,-,7.970,0.0386,$
155,30.0,0.101,0.109,0.070,6.290,-,7.970,0.0386,$
158,30.0,0.101,0.109,0.070,4.160,-,7.970,0.0256,$
159,30.0,0.101,0.109,0.070,4.160,-,7.970,0.0256,$
162,30.0,0.101,0.109,0.070,7.900,-,7.970,0.0485,$
C,,,,,,,,,
C *** STRUCTURE WALL TRUSSES,,,,,,,,,
104,30.0,0.101,0.109,-,-,0.090,8.214,-1.0,$
204,30.0,0.101,0.109,-,-,0.090,4.215,-1.0,$
154,30.0,0.101,0.109,-,-,0.090,16.547,0.0164,$
361,30.0,0.101,0.109,-,-,0.090,9.300,-1.0,$
385,30.0,0.101,0.109,-,-,0.090,9.300,-1.0,$
C,,,,,,,,,
C
```

Figure 2. NODE DATA CSV File

```
' NODE.BAS  Compiled using Borland TurboBASIC

  Y = INSTR(COMMAND$," ")
  INFILE$  = LEFT$(COMMAND$,Y-1)
  OUTFILE$ = RIGHT$(COMMAND$,LEN(COMMAND$)-Y)
  OPEN INFILE$ FOR INPUT AS #1
  OPEN OUTFILE$ FOR OUTPUT AS #2

20 INPUT #1, A$
  IF EOF(1) THEN STOP
  IF A$ = "C" OR LEFT$(A$,5) = "C ****" THEN
    PRINT #2, A$
    GOTO 30
  ELSE
    GOTO 20
  END IF

30 INPUT #1, A$
  IF EOF(1) THEN STOP
  IF LEN(A$) = 0 THEN GOTO 30
  IF A$ = "C" OR LEFT$(A$,5) = "C ****" THEN
    PRINT #2, A$
    GOTO 30
  END IF
  INPUT #1, B$, C$, D$, E$, F$, G$, H$, I$, J$
  IF EOF(1) THEN STOP
  A$  = STRING$(14-LEN(A$)," ") + A$ + ","
  B   = INT(VAL(B$))
  B1$ = STR$(B)
  IF LEN(B$) - LEN(B1$) < 2 THEN
    B$  = STRING$(12-LEN(B1$)," ") + B1$ + ".0,"
  ELSE
    B$  = STRING$(12-LEN(B1$)," ") + B$ + ","
  END IF
  I   = INT(VAL(I$))
  I1$ = STR$(I)
  IF I > 9 THEN
    I$ = I$ + STRING$(27-(LEN(I$)-LEN(I1$)-1)," ")
  ELSE
    I$  = " " + I$ + STRING$(27-(LEN(I$)-LEN(I1$)-1)," ")
  END IF
  IF LEFT$(J$,1) = "$" THEN
    J$ = LEFT$(J$,12)
  ELSE
    J$ = "$ " + LEFT$(J$,10)
  END IF
  PRINT #2, A$; B$; I$; J$

  GOTO 30
  STOP
```

Figure 3. NODE.BAS

```
C
C *** THE FOLLOWING NODES WERE GENERATED BY 'SAMPLE_N.XLS'
C *** ON 12 June 92, 2:49 PM
C *** DIMENSIONS ARE FROM CAD MODEL 'STRUCTURE.MF1;14' 04 JUNE 92
C *** ALUMINUM 2014-T6 PROPERTIES ARE FROM MIL-HDBK-5F, ROOM TEMP
C
C *** STRUCTURE NODES
C *** STRUCTURE TORQUE BOX
          102,          30.0, 0.0396                          $
          105,          30.0, 0.0396                          $
          108,          30.0, 0.0262                          $
          109,          30.0, 0.0262                          $
          112,          30.0, 0.0497                          $
          152,          30.0, 0.0386                          $
          155,          30.0, 0.0386                          $
          158,          30.0, 0.0256                          $
          159,          30.0, 0.0256                          $
          162,          30.0, 0.0485                          $
C
C *** STRUCTURE WALL TRUSSES
          104,          30.0, -1.0                            $
          204,          30.0, -1.0                            $
          154,          30.0, 0.0164                          $
          361,          30.0, -1.0                            $
          385,          30.0, -1.0                            $
C
C
```

Figure 4. Final NODE DATA Block

CONDUCTOR DATA for SINDA model 'SAMPLE.INP'											
This is spreadsheet file 'SAMPLE C.XLS'											
Cond Number	Node i	Node j	Cond-tivity	Thick-ness	Width	Length	Conduc-tance	Number Fasteners	Joint C'tance	Final C'tance	Comments
C											
C *** THE FOLLOWING CONDUCTORS WERE GENERATED BY 'SAMPLE C.XLS'											
C *** ON 15 June 92, 3:16 PM											
C *** DIMENSIONS ARE FROM CAD MODEL 'STRUCTURE.MF1;14' 04 JUNE 92											
C *** ALUMINUM 2014-T6 PROPERTIES ARE FROM MIL-HDBK-5F, ROOM TEMP											
C											
C *** STRUCTURE CONDUCTORS											
C *** STRUCTURE TORQUE BOX											
1	102	105	3.96	0.070	6.180	4.070	0.421	-	-	0.421	$
3	102	108	3.96	0.070	6.180	4.070	0.421	-	-	0.421	$
5	102	109	3.96	0.070	8.140	3.090	0.730	-	-	0.730	$
7	102	112	3.96	0.070	8.140	3.090	0.730	-	-	0.730	$
9	112	152	3.96	0.070	6.180	4.070	0.421	-	-	0.421	$
11	112	155	3.96	0.070	6.180	4.070	0.421	-	-	0.421	$
13	112	158	3.96	0.070	8.140	3.090	0.730	-	-	0.730	$
15	112	159	3.96	0.070	8.140	3.090	0.730	-	-	0.730	$
17	159	162	3.96	0.070	4.110	4.070	0.280	-	-	0.280	$
19	162	102	3.96	0.070	4.110	4.070	0.280	2	0.5	0.179	$
C *** STRUCTURE WALL TRUSSES											
51	104	204	3.96	-	0.490	4.360	0.445	-	-	0.445	$
53	204	154	3.96	-	0.490	4.360	0.445	-	-	0.445	$
55	154	361	3.96	-	0.490	4.150	0.468	-	-	0.468	$
57	361	385	3.96	-	0.090	4.880	0.073	-	-	0.073	$
59	385	104	3.96	-	0.090	4.880	0.073	-	-	0.073	$
C											
C											

Figure 5. CONDUCTOR DATA Spreadsheet

```
CONDUCTOR DATA for SINDA model 'SAMPLE.INP',,,,,,,,,,
This is spreadsheet file 'SAMPLE_C.XLS',,,,,,,,,,

,,,,,,,,,,
Cond,Node,Node,Cond-,Thick-,,,Conduc-,Number,Joint,Final,
Number,i,j,tivity,ness,Width,Length,tance,Fasteners,C'tance,C'tance,Comments

,,,,,,,,,,
C,,,,,,,,,,
C *** THE FOLLOWING CONDUCTORS WERE GENERATED BY 'SAMPLE_C.XLS',,,,,,,,,,
C *** ON 15 June 92,  3:16 PM,,,,,,,,,,
C *** DIMENSIONS ARE FROM CAD MODEL 'STRUCTURE.MF1;14' 04 JUNE 92,,,,,,,,,,
C *** ALUMINUM 2014-T6 PROPERTIES ARE FROM MIL-HDBK-5F, ROOM TEMP,,,,,,,,,,
C,,,,,,,,,,
C *** STRUCTURE CONDUCTORS,,,,,,,,,,
C *** STRUCTURE TORQUE BOX,,,,,,,,,,
1,102,105,3.96,0.070,6.180,4.070,0.421,-,-,0.421,$
3,102,108,3.96,0.070,6.180,4.070,0.421,-,-,0.421,$
5,102,109,3.96,0.070,8.140,3.090,0.730,-,-,0.730,$,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
7,102,112,3.96,0.070,8.140,3.090,0.730,-,-,0.730,$,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
9,112,152,3.96,0.070,6.180,4.070,0.421,-,-,0.421,$,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
11,112,155,3.96,0.070,6.180,4.070,0.421,-,-,0.421,$,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
13,112,158,3.96,0.070,8.140,3.090,0.730,-,-,0.730,$,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
15,112,159,3.96,0.070,8.140,3.090,0.730,-,-,0.730,$,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
17,159,162,3.96,0.070,4.110,4.070,0.280,-,-,0.280,$,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
19,162,102,3.96,0.070,4.110,4.070,0.280,2,0.5,0.179,$,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
C *** STRUCTURE WALL TRUSSES,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
51,104,204,3.96,-,0.490,4.360,0.445,-,-,0.445,$,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
53,204,154,3.96,-,0.490,4.360,0.445,-,-,0.445,$,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
55,154,361,3.96,-,0.490,4.150,0.468,-,-,0.468,$,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
57,361,385,3.96,-,0.090,4.880,0.073,-,-,0.073,$,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
59,385,104,3.96,-,0.090,4.880,0.073,-,-,0.073,$,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
C,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
C,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
```

Figure 6. CONDUCTOR DATA CSV File

```
' CONDUCT.BAS  Compiled using Borland TurboBASIC

  Y = INSTR(COMMAND$," ")
  INFILE$  = LEFT$(COMMAND$,Y-1)
  OUTFILE$ = RIGHT$(COMMAND$,LEN(COMMAND$)-Y)

  OPEN INFILE$ FOR INPUT AS #1
  OPEN OUTFILE$ FOR OUTPUT AS #2

20 INPUT #1, A$
  IF EOF(1) THEN STOP
  IF A$ = "C" OR LEFT$(A$,5) = "C ***" THEN
    PRINT #2, A$
    GOTO 30
  ELSE
    GOTO 20
  END IF

30 INPUT #1, A$
  IF EOF(1) THEN STOP
  IF LEN(A$) = 0 THEN GOTO 30

  IF A$ = "C" OR LEFT$(A$,5) = "C ***" THEN
    PRINT #2, A$
    GOTO 30
  END IF

  INPUT #1, B$, C$, D$, E$, F$, G$, H$, I$, J$, K$, L$
  IF EOF(1) THEN STOP

  A$  = STRING$(14-LEN(A$)," ") + A$ + ","

  B$  = STRING$(11-LEN(B$)," ") + B$ + ","

  C$  = STRING$(7-LEN(C$)," ") + C$ + ","

  K   = INT(VAL(K$))
  K1$ = STR$(K)
  K$  = STRING$(7-LEN(K1$)," ") + K$ + STRING$(18-(LEN(K$)-LEN(K1$)-1)," ")

  IF LEFT$(L$,1) = "$" THEN
    L$ = LEFT$(L$,12)
  ELSE
    L$ = "$ " + LEFT$(L$,10)
  END IF

  PRINT #2, A$; B$; C$; K$; L$

  GOTO 30
  STOP
```

Figure 7. CONDUCT.BAS

```
C
C *** THE FOLLOWING CONDUCTORS WERE GENERATED BY 'SAMPLE_C.XLS'
C *** ON 15 June 92, 3:16 PM
C *** DIMENSIONS ARE FROM CAD MODEL 'STRUCTURE.MF1;14' 04 JUNE 92
C *** ALUMINUM 2014-T6 PROPERTIES ARE FROM MIL-HDBK-5F, ROOM TEMP
C
C *** STRUCTURE CONDUCTORS
C *** STRUCTURE TORQUE BOX
              1,         102,      105,      0.421                $
              3,         102,      108,      0.421                $
              5,         102,      109,      0.730                $
              7,         102,      112,      0.730                $
              9,         112,      152,      0.421                $
             11,         112,      155,      0.421                $
             13,         112,      158,      0.730                $
             15,         112,      159,      0.730                $
             17,         159,      162,      0.280                $
             19,         162,      102,      0.179                $
C *** STRUCTURE WALL TRUSSES
             51,         104,      204,      0.445                $
             53,         204,      154,      0.445                $
             55,         154,      361,      0.468                $
             57,         361,      385,      0.073                $
             59,         385,      104,      0.073                $
C
C
```

Figure 8. Final CONDUCTOR DATA Block